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AUTOMATED INTELLIGENCE FOR THE TACTICAL ARMY 1980/1990

28 MAY 1969

U.S. ARMY
ADVANCED MATERIEL CONCEPTS AGENCY

WASH DC 20315 AD HOC REPORT 4

AUTOMATED INTELLIGENCE FOR THE TACTICAL ARMY, 1980/90

AHWG #4

Exploratory Evaluation Division
US Army Advanced Materiel Concepts Agency
Washington, D. C. 20315

28 May 1969

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ABSTRACT

The purpose of this study is to explore advanced materiel concepts for computer-aided processing, evaluation and analysis of combat information in the US field army of 1980/90. The scope covered includes discussion of computer ideas, methods, technology and equipment which appear attainable in the cited time frame to supplement or replace principal functions now performed by the tactical intelligence analyst in the various field army echelons. ( )This report is not meant to be a long range technological forecast; the material in this report is a compendium of an Ad Hoc Working Group (AHWG) convened by the US Army Advanced Materiel Concepts Agency, Washington, D. C. 20315. Constructive comments to extend and increase the substantive value of any ideas in this report should be forwarded by any reader to the Director of AMCA.

The emphasis in this AHWG effort was on the identification of automated data handling techniques to assist the intelligence decision process. The AHWG explored the nature of the evaluation, integration, interpretation, and dissemination functions performed by tactical intelligence analysts in both existing and planned Army systems. Emphasis was placed on automation of the analyst's judgmental and decision processes, on the data available and actually used, on the time constraints, and on the kinds of errors or misjudgments that should be overcome. Automated techniques which promise to enhance the ability of the analysts to meet their decision requirements were identified.

The AHWG concluded, in part, that:

a. A wealth of, if not excessive, combat data will be available to the future intelligence analyst at field army headquarters.

b. The future intelligence analyst can take on the expected increase in data volume with ADP aids. He can improve speed, accuracy and the number of his intelligence statements by use of modern data processing equipment.

c. The 1990 advances in hardware will be at least as advanced as the software.

d. The software for a partial machine assisted intelligence system is available. The software for advanced intelligence systems is attainable within ten years, and appears to warrant the effort. The ultimate automatic intelligence system (where the human only spot checks the ADP process) is very far away; whether a heavily concentrated effort toward mechanizing the human thinking process would succeed within only twenty years is very doubtful.

The AHWG recommended, with some specificity, that a number of development programs and areas for further exploratory evaluation should be pursued by the United States (military, civilian users and/or manufacturers). In part, these recommendations themselves (or their pursuance) constitute evidence of useable advanced materiel concepts for ultimate inclusion in QMDO Plans and similar guidance documents.

More details on the Background, Objectives, Scope and Specific Tasks addressed by the AHWG are in the Introduction, Section I of this report (see Table of Contents, page iii).

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SECTION I - INTRODUCTION

From 2-5 December 1968, the Advanced Materiel Concepts Agency assembled an Ad Hoc Working Group (AHWG) to discuss ways and means to assist the 1980/90 Intelligence Officer (IO) at the Field Army by automatic data processing. Rather than furnish minutes of the meeting to attendees, the material discussed was consolidated into this report. The earlier "Assumption" paragraph has been replaced by "Forecasts."

The study yielded qualitative responses to most pre-set objectives; predicted information-input sources and rates are so varied and depend on so many factors that they, as with all the other AHWG objective items, may warrant further studies. The other points under "objectives" in the guidance were met to the extent that time permitted.

A. BACKGROUND DISCUSSION

The Army in the 1970/80 period is planning to develop a number of specialized computerized systems for receipt, processing, storage, retrieval and display of different types and amounts of military data. Perhaps nowhere is the requirement for efficient data handling techniques greater than in the area of tactical intelligence information processing. Comprehensive and accurate summaries of enemy intention, disposition, strength, and status must be produced as quickly as conceivably possible if commanders are to make optimal battlefield decisions.

To help meet this need, the Department of the Army has expended extensive research effort over the past decade to improve target acquisition, reconnaissance and surveillance, and other intelligence collection capabilities. The amounts and kinds of information that must be integrated into intelligence analyses has subsequently greatly increased. The need for continually updating intelligence appraisals while evaluating and absorbing increased information imposes a severe burden on the intelligence analyst. He must judge source reliability and information credibility, determine information relevancy and decay rates, and consider information gaps while integrating large amounts of different kinds of information.

The emphasis in this AHWG effort was on the identification of automated data handling techniques to assist the intelligence decision process. The AHWG explored the nature of the evaluation, integration, interpretation, and dissemination functions performed by tactical intelligence analysts in both existing and planned Army systems. Emphasis was placed on automation of the analyst's judgmental and decision processes, on the data available and actually used, on the time constraints, and on the kinds of errors or misjudgments that should be overcome. Automated techniques which promise to enhance the ability of the analysts to meet their decision requirements were identified.

B. OBJECTIVES OF AD HOC WORKING GROUP

1. To discuss advanced materiel concepts, based upon accepted Army intelligence doctrine and practice, and to examine, describe, and validate computer-automated logic processing for effective analysis and interpretation of combat information into combat intelligence for the 1980/90 Field Army.

2. Discuss and document the input sources and rates, internal data handling techniques, and actual and desired output parameters of existing and planned battlefield intelligence systems.

3. Determine the decision functions, the mental data handling requirements, and the response requirements of future Field Army intelligence analysts.

4. Discuss projected hardware and software state-of-the-art in the 1980/90 period with a view toward identifying data handling techniques which can facilitate analyst decision functions and meet anticipated input/output demands.

5. Identify promising specific techniques consonant with future state-of-the-art which can be evaluated in follow-on experimental laboratory studies to determine whether analyst's decision processes can be enhanced through automatic or semi-automatic aids.

C. SCOPE

1. The AHWG considered future technical means and methodologies to aggregate and analyze intelligence information from field army sources through automatic data processing techniques. Required elements for future systems reviewed were: ideas to process raw input data through a logic process that includes recognition, selection, and correlation with established intelligence-production criteria; input information filtered for relevance and avoidance of duplication, and evaluated for reliability and accuracy; data purged from memory when determined to be obsolete; and dynamic update.

2. Methods of development considered by the AHWG were:

a. Pattern recognition defined by specified parameters to extract pertinent information from the data flow.

b. Aggregate data containing collatable information into an accurate and reliable output as "intelligence items."

c. Identify time-dependent traces or trends subject to decay if not reinforced.

d. Use of mathematical models and statistical techniques with "standard" parameters to accept a "decision" based upon input information, or reject the "decision" until additional input data are obtained to exceed a decision threshold, acceptable within specified confidence limits.

e. Teaching of a computer through an orderly routine to perform information collation in a field army intelligence process.

f. In addition, the study action officer and the ad hoc group conducted a review of intelligence processing in the future field army to determine a general approach to the automated logic process. Intelligence analysts, training agencies, literature, and doctrine were contacted and reviewed to determine the general parameters required. From this review, the AHWG developed specific aggregations of input data in conformance with human thinking procedures used to process information into intelligence. Finally, by investigation of prognosticated future computer technology, the AHWG structured machine procedures to achieve results equivalent to those achievable by trained intelligence personnel using identical input data in that time frame.

D. SPECIFIC TASKS ADDRESSED BY THE AD HOC WORKING GROUP

1. Functional Analysis. Through such means as reviewing literature, known to AHWG members, analyzing doctrine, examining operational procedures, and studying actual or anticipated inter- and intra-system information flow, a functional analysis was made of the role of intelligence analysts in current and future battlefield systems. In discussing input sources and rates, internal data handling techniques, and output parameters, explicit attention was given to the demands these factors place on the intelligence analyst.

2. Decision Processes. What the analyst should or must do to meet the demands placed on him under battlefield conditions was discussed. The reactions of analysts to the kinds of data that impinge upon them were addressed in an attempt to discover what kinds of data analysts tend to actually use, what data they ignore, what data they store and retrieve, and when and how they would like data displayed. How the data is subjectively weighed, integrated, and evaluated by the analyst was also explored. Attempts were made to determine what happens subjectively when particularly good or poor intelligence appraisals are made by analysts: what kinds of inferences, problem solving techniques, and the like are employed? What errors or misjudgments are incurred? How the mental processes of the analyst are affected by such factors as fatigue, anxiety, stress, time constraints and stringent reporting requirements were also explored in an attempt to study the subjective demands placed on analysts. Ideal (from an analysts's point of view) conditions and data for making decisions were formulated in current and future systems.

3. Hardware and Software Projections. The anticipated state-of-the-art in the 1980/90 period were studied with a view toward identifying techniques which might facilitate analyst decision functions. Promising decision techniques were identified through human factors, experimental psychology, and cognition or decision process approaches.

4. Specific Decision Approaches. Promising techniques were identified and elaborated. The manner in which the techniques could be employed within an advanced computerized intelligence system was discussed. The hardware and software necessary to implement the aids were reviewed. The procedures through which an experimental evaluation of the promising techniques can be conducted were outlined.

SECTION II - FACTS ABOUT INTELLIGENCE, ADP HARDWARE AND SOFTWARE, AUXILIARY MATERIAL

A. PROCEDURES AND GOALS OF INTELLIGENCE

1. At all levels of command, the activity of the Intelligence Officer (IO) follows a four step cycle: collection of information; processing the information; dissemination and use of the resulting intelligence; planning further collection efforts and orders. The first two of these steps are explained in detail in the following paragraphs.

a. Collection of Information. The information is primarily collected from sources such as enemy activity, prisoners of war, local civilians, recovered military personnel, captured enemy documents, enemy material, enemy signal communications and other electromagnetic emissions, duds, shells and missile fragments, craters, contaminated areas, nuclear bursts, ground and aerial photographs, maps, weather forecasts, studies and reports of civilian agencies. The IO receives this information generally in the form of a written report; the information is usually restricted to the immediate battlefield area, ie., the first ten kilometers in depth, which may not be true for other than very slow-moving conflicts.

b. Intelligence Information Processing. The IO processes the information by recording, evaluation and interpretation. Recording is the first step in the data reduction process and consists of categorizing and sorting. Evaluation is a critical appraisal of the information concerning pertinence, accuracy and reliability of the source, graded in six levels; essentially, the evaluation is a correlation between the reports themselves and with the data base. In the interpretation process, the possible meaning of the item is determined; this may include analysis, synthesis or integration and formation of conclusions, the building of a hypothesis. So far, a clear definition of the mental process leading to the right conclusion could not be found; this is also true for intermediate decision-making in industry, so no aid can be expected from there. A recent study in this area has been contracted for by ARO and USACDCINTA with Bolt, Beranek and Newman, Inc.

2. End Product of Intelligence. The end product of the IO's activity are automatic reports on all changes within the enemy's territory and answers to specific questions from the commanding officers. To this end, he sets up a list of key indicators which substantiate the hypothesis. Items used as key indicators are:

a. Identification of enemy units.

b. Strength of enemy units.

c. Tactics and training.

d. Disposition, location and deployment.

e. Logistics, primarily supply routes and means.

f. Key personnel, background and history.

g. Special items, equipment.

h. Identification aids like code numbers used in communications.

i. Geographical indices.

The key indicators are not used uniformly and study still goes on. Based on the IO's output, lower echelon reports and higher echelon requirements, command plans ahead 24 hours at the division level and five days at the corps level.

B. HARDWARE

1. Computer Hardware in Existence. Deployed computer hardware to collect, process, interpret, display and disseminate tactical information is known to exist in the Air Force (the 407L and the AN/TSQ-91 in development), the Navy (Navy tactical data system) and an experimental system in the Army (TOS); FADAC is a fire control system, to be replaced by TACFIRE, and there are business computers used for logistics. Of these, only TOS is of interest as an automated system for tactical intelligence data, i.e., once TOS is augmented by a tactical display system capable of showing annotated situation maps side-by-side with graphical/alphanumeric data for the command staff.

2. Computer Driven Large Screen Displays.

a. The tactical display will remain a problem for some time to come:

(1) A military type laser display being developed by the Air Force did not turn out usable at this time. The control of the beam was too slow. The colors specified could not all be produced.

(2) Sandia Corporation at Albuquerque, New Mexico is developing a see-through display. The problem is that the change is slow--100 micro seconds per point--black and blue cannot be produced satisfactorily and so far only a chip of minute dimensions was manufactured, i.e., mass production has not been proved yet.

b. The only existing displays, operational with full color capability are:

(1) Datachrome by ITT. Each change in the displayed material requires the generation of a new color slide with a delay of several seconds. This system was used in NORAD and SAC--the 473L system.

(2) Projection system with background projector for maps, etc. and projection plotter with an "erase" feature, based on blackening of an extra layer on the slide by controlled ultra-violet light; the scribing pin can be replaced by a symbol which can be moved over the display area. NASA uses these displays extensively in the Houston Manned Spaceflight Center. The lamp life is restricted to 50 to 100 hours. Automatic exchange is possible.

(3) The Eidophor system used for large screen displays in movie theaters, etc. It has full color capability. Disadvantages are:

(a) It needs a refresher memory and a scan converter.

(b) The three cathodes must be replaced every fifty to one hundred hours.

(c) The three cathode ray tubes must be pumped continuously to maintain the vacuum in the presence of the oil necessary for the formation of the picture.

The FAA cancelled its effort to use Eidophors in air traffic control centers. The Air Force points to excessive sensitivity to environmental heat.

(4) A light-valve system which replaces the oil by thermo- or photo-plastic films; erasure time is around a second (too long) and total erasure is necessary for updating; the number of erasures is limited to one hundred per film picture area. The FAA considers the photochromic display to be inadequate because the white background causes eye fatigue. The Air Force lists as disadvantages the necessity to erase all information on the image carrier before updating, screen burn-in and poor resolution.

(5) Large screen CRT projection has limited brightness and requires frequent change of the CRT due to phosphor burn-in.

(6) Electroluminescent displays are on-off devices (no brightness control), no large units have been produced since over a million picture elements must be physically manufactured.

(7) Opto-magnetic displays require a large number of components which makes manufacture difficult; the lack of easy background slide projection is not really serious because this information can be produced by the computer; has color capability (Radiation Inc.).

3. Computer Main Frame and Peripherals.

a. Direct man-machine communication. The IO can interact with the computer with existing graphic remote terminals such as the IBM type 2250 (CRT display with alphanumeric and line drawing capability, typewriter keyboard, overlay keyboard and lightpen; displayed information is stored within the unit).

b. Compact computer main frame. For the IO's data processor needs, computers of small volume of one to six cubic feet and lightweight are on the market with comparatively excellent performance. They allow remote terminals, real-time input/output and an array of peripherals, beside logic and arithmetic data processing.

c. Large file storage. The emphasis is on a large data base which is constantly being worked on and which must have for that reason a short access time. Very compact mass storage devices for billions of characters are not available; flat magnetic film strips as used by the IBM data cell and RCA's film strip memory have the necessary capacity, but not the necessary access speed and excessive weight and volume. Magnetic tape units are inadequate in all three respects.

d. Remote station to central processor communication, sensor inputs. Real-time input/output channels are well developed and widely in use; so are data communication means. Channel-to-channel communication between computers is widely practiced (connection of intelligence computer to TOS, and although not contemplated for Army 75, will surely be a goal for LCSS-90).

e. (The paragraph of text pertaining to Automatic Sensors on which separate action may be taken in the future by AMCA was originally written for this space and has been omitted because of its classification as Confidential. Its omission in no way detracts from the continuity of the other material herein, nor is its contents at all essential for the understanding of this report. Copies of this paragraph will be on file and may be consulted at offices of the Exploratory Evaluation Division, USA AMCA.)

f. Textual computer inputs. Automatic page readers for machine printed material are about to replace punched cards in civilian data processing to a large extent over the next few years; many companies manufacture them, some even read hand-printed script. Machine reading of longhand is accomplished in the laboratories. Russian reports indicate that similar results are being achieved with Cyrillic script. Nothing is known about automated reading of Chinese or similar ideographs, except that experiments dealing with stroke analysis are in progress.

g. Hard copy outputs. There is a large selection of hard copy output devices from typewriter to high speed printer, microfilm/microfiche production, Xerographic printers and ink-spray printers. Also

marketed are plotters and the photographic output media can also present graphs and plots. Most have many moving parts with close tolerances.

h. Film reading equipment. Automatic film readers already draw maps from aerial photographs, classify microscoped bodies, determine attitude of flying missiles and extract signature data from A-scope films. This will aid in rapid extraction of surveillance data from aerial photographs with direct computer input.

i. Voice communication with the computer. Audio input and output to and from digital systems is no problem per se. Voice interpretation appears frequently in reports. Speaker identification by voice print is already in use though not automated.

j. Immediate hand print and sketch input. For computer input by untrained personnel, RAND developed the RAND Tablet, a flat sandwich that gives the coordinates of a point touched with a pencil for written information and hand sketches.

k. Power supply. Field units need primary power sources. The gasoline engine powered generator is practically the only system considered for larger field installations; the fuel cell is just coming up and only quite recently an automobile gas burning cell worked as a prototype. SNAP and nuclear power reactors are being explored; both require heavy shielding; the SNAP's deliver about 100W and the power reactor is in the megawatt range. Chemical primary batteries are much improved.

C. <u>SOFTWARE</u>

1. For a system such as the one producing intelligence automatically, the general rules for its realizeability are noted below. The manner in which these will be designed into hardware must remain for subjects of more detailed engineering development studies.

a. The system must be expressable in logically formulated laws.

b. These laws must be known.

c. The initial state of the system must be known.

d. The influence of the environment must be known.

e. The computation for the selections to be made must take place within a shorter period of time than is required to put these selections in effect, i.e., the delay through the control mechanism has to be small enough to lead to the desired effect.

2. These rules must be complemented by hardware restrictions:

a. The program must fit into the computer system, i.e., the number of instructions in the programming system must be smaller than the primary working storage of the machine, such as core, drum, disc or extended core storage.

b. The program must allow partitioning such that storing parts in slower access media such as drum and disc does not lead to prohibitive delays.

c. The program must in all parts use execution times shorter than the permissible delay. Actually, this and the previous rule interact.

d. The instructions required by the program must be realizeable logically or by analog methods.

3. Software for Intelligence Information Recording. To execute his first function, recording, i.e., categorizing, sorting and storing, the IO has already the beginnings of programming support such as the PACAF/IDHS formatted file system of the Air Force (Intelligence Data Handling System, DDC #AD 818 818, June 1967). The features of this system are:

a. File creation or initialization; accept a variety of input data formats; accept strings up to 965 characters; some editing.

b. File maintenance; provide simple maintenance/expansion and instruction procedures.

c. File structuring; structure and restructure data files to user specifications as user requirements vary.

d. Query processing; provide a variety of retrieval modes.

e. Output processing; sequence and output the retrieved data, to user specifications as user requirements vary.

f. Internal operating control to minimize operator intervention.

g. Modularity; utility routines can be inserted or removed as required.

h. The file is on tape; the machine has very small core storage--vis the limitation on the data string. Editing is limited to:

(1) Free alpha data from numerics.

(2) Free numeric data from alphas.

(3) File sequences with up to 10 major and 10 minor sort-control fields.

(4) Files contain logic blocks of three records each; fixed description of subject, periodic/variable data and a comment record, a free textual summary about the subject.

i. Retrieval is performed either by a logical, a special processing program segment or by a combination of both; the logical processor produces logical or historic data sets, the special processors perform Route, Irregular Area or Point Radius search. Logic connectors are IF, AND, OR and LIMIT, operators are EQUAL, UNEQUAL, LESS THAN and GREATER THAN. The output is controlled by cards inserted in the deck before run time; it can be print, mag tape or punched card. The program has an error detection (errors caused by hardware) and prints out the presence of errors if they cannot be corrected automatically. The complete program consists of a "systems program," a supervisor which calls utilities such as the search routines or card-to-tape conversion. Required is an IBM 1401 Mod C special features computer, read/punch, printers and tape units. TOS is intended to have this capability on a much larger basis, though not intended only for the IO use. The Defense Documentation Center uses a UNIVAC 1107 with over a dozen tape drives and thus is a major data storage and retrieval center. The Information Storage and Retrieval Science is now 15 years old and thus can be expected to be of excellent help to the IO.

4. Intelligence Information Evaluation Programs. Evaluation as the second step in the IO's information processing is on a higher level. Pertinence of the information and reliability of the source can be entered into the data file in the editing process since the parameters for pertinence and source do not vary appreciably; accuracy, determination and correlation with other reports demand software features similar to the interpretation, so it is considered in the following paragraph.

5. Software for Intelligence Interpretation. Interpretation is a process whose automation even in part makes artificial (in contrast to human) intelligence an integral part of the software. The first step to artificial intelligence (AI) is a clear understanding of human intelligence. A DDC report (Clearinghouse Report No. N68-15996, AN EXPLORATORY STUDY OF INDIVIDUAL INFORMATION PROCESSING AND DECISIONMAKING) states a result, "an individual's information-processing efficiency, his image state (state of knowledge) for a particular task, his risk-taking propensity, and the result rating of the task in terms of meeting specified objectives and constraints appear to impinge significantly upon the set of variables (representing the individual, task and interaction domains) in the formation processing domain." This and other reports suggest that the inroads to AI are relatively small notwithstanding some surprising isolated successes: chessplaying programs play now at the level of good amateurs--two moves look-ahead; theorem proving in geometry and basic mathematics; a conversational program to maintain "small talk."

An effort was made to analyze scenes and geometric (sterometric) configurations. This is considered a step in the direction of automatic evaluation of aerial and ground photographs and TV picture representations with regard to position (linear and angular). More work is reported on pattern recognition; the general case is treated in "APPLICATIONS OF INFORMATION MEASURES TO PATTERN RECOGNITION" (AD 812 764) where solutions are presented and a formalism given to compare the usefulness of the solutions in particular cases; the solutions are in the form of "Minimax uncertainty rules." Unlike artificial intelligence, pattern recognition arrives at "conditional" answers and offers the prospect to be a valuable instrument for the IO. Auto and cross correlation are together with non-linear methods fairly well worked out in the discreet and continuous function areas.

6. Ancilliary Utilities.

a. Language processing. Present programs can understand English text limited to very basic semantic and five hundred words. Automatic translation handles practically complete sets of words with semantic capabilities (the computer does not have to understand the text).

b. Page reader programs for machine or handprinted scripts have already reached a certain sophistication; for English they can be considered as perfected.

7. Considerations. Several years ago it was reported that a program exists which can prove theorems treated in "Principia Mathematica," the most comprehensive collection of mathematical material. Not mentioned was the fact the Principia start with the elementary theorems, some of which were actually machine-proved.

SECTION III - FORECASTS

The following paragraphs deal with extrapolations of the present state-of-the-art discussed in the previous Section. These forecasts can be thought of as conservative, but, a word of caution: forecasting software developments for certain time frames is nearly impossible; it will be recalled that IBM introduced the system 360 hardware in steps starting in 1965. The supporting software, i.e., compiler/assembler, programming system, operating system and its utilities was introduced two to three years later due to its totally unexpected complexity and despite a staff of over 1200 programmers; CDC had a similar experience before with its large 6600 computer operating system.

A. PROCEDURES AND GOALS IN INTELLIGENCE

The conflicts may be low intensity, conventional or limited nuclear. The organizational structure may essentially remain the same. The basic objectives and concepts of intelligence may vary little over the next twenty years. The increasing mobility of the ground forces may demand faster, more efficient intelligence in a growing number of fields. Much more data may be available demanding mass data processing.

B. COMPUTERS AND LOGIC

1. Theory. Logic, sequential circuit and machine theory have, and will in the future, present new possibilities. Many are urgently needed for successfully using large scale integration, and to implement automata arising from research in artificial intelligence and cybernetics. In the area of logic, the theories for multivalued logic and threshold elements will be ready in time for use in large scale integration systems, i.e., in five years. Multivalued logic is not likely to find its way into the logic array as long as "precision" resistors cannot be implemented on a silicone chip; high amplification factors between logic levels require multi-stage amplifiers with longer delays. Threshold logic is in a similar situation. Sequential circuits will at least for some time, perhaps ten years, provide a rudimentary computer capability at the very low echelons; eventually, these too will be general purpose computers with a fixed special purpose program. Machine theory will further stake out the capabilities of computers and computer systems, and thus set the upper limits to artificial intelligence (mechanized thinking). The interconnection between large scale integration chips with their much increased gate-to-pin ratio poses a serious problem which is just now being attacked by machine partitioning theory. Since this is one of the keys to make the computer a household appliance, a solution is eagerly sought by the industry.

2. Technology. Medium scale integrated circuits, defined as having about one hundred gates, are entering the field of small and special computers. Large scale integrated circuits suffer from very low yields in production and have to resort to discretionary intraconnecting, a

costly process involving an automatic tester and a computer. It can safely be assumed that by 1974 four hundred gates per chip will be achieved, by 1980, 5,000 and by 1990, 100,000. By 1980 a personal computer is a possibility, in the size of a microfiche, one half inch thick sandwiched between a writing surface (RAND Tablet) and a flat display.

C. PERIPHERALS

The computer peripherals will use fewer moving parts. A step in this direction is the ink spray printer. Card equipment will be greatly reduced in use and page readers will dominate the commercial scene within ten years. Large mass storage will be reduced in weight and volume. Photochronic storage devices may lead to a capacity of 10^9 words in the space of one cubic foot within ten years. Large screen flat displays will be operational by 1980. Prototypes of laser diode displays for digital meters have appeared in this country and in Japan.

D. (The paragraph of text pertaining to Automatic Sensors on which separate action may be taken in the future by AMCA was originally written for this space and has been omitted because of its classification as Confidential. Its omission in no way detracts from the continuity of the other material herein, nor is its contents at all essential for the understanding of this report. Copies of this paragraph will be on file and may be consulted at offices of the Exploratory Evaluation Division, USA AMCA.)

E. DATA TRANSMISSION

The near-saturation of the electromagnetic spectrum will prevail until data compression at the source (and elimination of redundant and irrelevant data) reduces the data volume drastically, i.e., until extremely cheap computers are available (computer on a chip: for possibly $100) in ten to fifteen years. Until then, the Army will have standardized data transmission formats, signal levels and connectors; the communication equipment will be modular and reduced in number of types. The speeds of data communication, wording, storing and access will be compatible and adequate. For the near future, the security and freedom from errors in transmission are interdependent and difficult to achieve on the battlefield. The limited information at hand at this time does not indicate a solution for the time frame considered.

F. GENERAL

If the general rules are met, and if the problem(s) are already logically formulated, the program needed for 1980 military use could run within five years; if the problem is logically formulated but it is not proven that it can be treated mathematically, it may take ten years; if the problem is formulated verbally but not logically, a full twenty years may be required.

a. Information Storage and Retrieval. Any problem here could probably be solved within five years; the PACAF/IDHS is estimated to have used up about fifty man-years, and for its features on such a small machine as the IBM 1401 it is quite an accomplishment.

b. Automatic Editing/Abstracting. Abstracting was done over ten years ago on the IBM 704. Programs for automatic abstracting/editing should operate within five years after conception.

c. Pattern Recognition. The many applications of pattern recognition brought forth many projects whose results suggest that specific automatic intelligence problems can have solutions within five to ten years.

d. Correlation. All problems depending on correlation methods seem to be solvable within five years after formulation.

e. Artificial Intelligence. For this complex, no forecast is possible since science is still busy with the formulation. The automation of physical human activity poses no serious problems because it is controlled mostly by reflexes which are predictable; the human thinking process is not necessarily predictable although the solution gained intuitively is acceptable.

SECTION IV - DISCUSSION

The following paragraphs represent the essence and flow of the discussion of the AHWG.

A. PROCEDURES AND GOALS

The increase in volume of collected information makes automated building of a data base mandatory since the IO cannot immediately assimilate and use more than a small part of the incoming data. Data from different sources concerning the same event are not really redundant if considered as verification of information. Irrelevant data cannot be avoided and its total may increase; these do not have to be a burden to the IO if the computer removes them before they even reach him; but these are of course reviewed before throw-away to obviate potential enemy counter-intelligence activity. The reports from human sources are already standardized, but the real information usually appears in the narrative part. For computer input, this narrative part may have to be modified to become strictly formal (ten to fifteen years from now this restrictive format may be freer). Automatic sensor inputs will follow established methods such that they enter the computer and the program knows where to store them; any time-sharing program performs this task. The analyst in the automated system is expected to: check on and influence the processing of the information; check validity of the generated intelligence. Automation is thus restricted to secondary tasks, mostly tedia. These tedia can reasonably be expected to be programmable. Analysts tend to be conservative; a combined man-machine assessment may take out this tendency. The process to integrate the pieces of information into intelligence, i.e., definite statements of tactical value have not been defined in its entirety. For one, there is the difficulty the IO has in analyzing the steps he takes in this process a good part of which is intuition--in the analytical treatment--or an accumulation of information that forms in the mind of the IO a pattern, unconsciously, commonly called a hunch, giving rise to a systematic search for supporting facts--in the building of a hypothesis. A good argument for the definition of these processes by the help of a systems analyst can be found in Appendices C and D. Pattern recognition would correspond to collecting the facts with an open mind, to build up a matrix and "recognize" the matrix as being similar to one stored which has a defined tactical meaning. An account of the analysis required is in Appendix C. In the automated system, the computer would try pattern recognition and the IO would influence the process according to his intuition. The IO then would determine if the product has tactical significance to justify immediate human intervention through direct communication to command, or to be entered in the tactical display, or to be stored for reference. The presently used mathematical intelligence analysis programs do not always work and this situation will not dramatically change; this is one reason for having the IO interact with the automatic process.

Another reason is to keep the IO aware of the situation so he can take over immediately in case of a malfunction of the data processor. The case that a whole command becomes inoperative makes a centralized system undesirable. At least information on neighboring areas should be available to the concerned neighboring units and accordingly lower commands should have information on their neighbors, and communication between them and across command lines. Thus, the impact of a division command post cannot cause a total intelligence blackout at higher (corps) command for this division's area.

B. HARDWARE

TOS is designed for appropriate echelons in the field army; no equivalent system for higher command is being developed. It has information storage and retrieval features usable for intelligence; 99% of the data can be retrieved by modifying the search term. Pattern analysis is used to obtain data on enemy movements and activities. Although DA and CDC now plan to use a version of TOS for intelligence, its use for intelligence analysis (although possible) does not appear fully advisable; the intelligence processing taxes the storage media to the absolute limits, the input/output channels move great amounts of data and there is raw material in storage unusable for command yet sensitive to compromise. (See Appendix B)

C. SOFTWARE AND METHODS

In detail, methods used in the automated analysis could be data derived dynamic indices with automatic cross correlation. New methods and techniques should be reviewed as to their usefulness in intelligence such as data reduction factor interaction, evaluation of the software's own performance. Information could be arranged in a weighted matrix for a moderate data set. Manual, machine assisted manual and automatic systems could be set side by side to compete with each other to determine their respective capabilities. This exercise could be repeated from time to time as hardware and software improve. It would be useful if a new type of warfare environment for intelligence information could be modeled or simulated to permit easier evaluation of the above methods. It cannot be expected, though, that an integrated system will, at some time in the future, deploy troops to maintain equilibrium between hostile and friendly forces automatically.

SECTION V - CONCLUSIONS

1. A wealth of, if not excessive, data will be available to the future IO.

2. The IO can take on the expected increase in data volume with ADP aids. He can improve speed, accuracy and the number of his intelligence statements by use of modern data processing equipment.

3. The hardware will be at least as advanced as the software.

4. The software for a partial machine assisted intelligence system is available. The software for advanced intelligence systems is attainable within ten years, and appears to warrant the effort. The ultimate automatic intelligence system (where the IO only spot checks the ADP process) is very far away; whether a heavily concentrated effort toward mechanizing the human thinking process would succeed within only twenty years is very doubtful.

SECTION VI - RECOMMENDATIONS

It is recommended that the US Army:

1. Initiate a machine assisted intelligence system prototype exploratory development on a base more advanced than TOS, for field use in 1980/85 with characteristics as follows:

   a. A goal should be to establish a concept of processing and evaluating of information into intelligence which represents a significant improvement over the file-oriented systems now available.

   b. The hardware for the field army should allow the IO to enter written documents to call, update, modify and delete information on a CRT-keyboard-coded pushbutton panel terminal with one second response time maximum, to receive data reports and automatic sensor outputs over data communication equipment and to transfer intelligence to the tactical computer for group display, large storage, an array of small simplified tape units and direct data input/output channels with minimum appropriate peripherals.

   c. The hardware for echelons below the division should have a teletype combined with a small preprocessor for message compression, en-decrypting, etc. Automatic sensors should also have preprocessors where applicable, the deployment being experimental.

   d. Software should include operating system with multiprogramming feature, real time monitor, information storage and retrieval, conversions and error indicators on line queries, maintenance and output.

2. Initiate plans for a follow-up 1990/95 system to establish a concept of man-assisted automatic intelligence, with a larger capacity main frame than present day equipment. The software should include automatic categorizing, editing, pattern recognition, correlation, special report generation, direct situation map entry, and compacting of data. The new warfare environment should be such as to facilitate the construction of the above capabilities within the system. The intelligence system should then indicate the need for technical countermeasures and perhaps activate them automatically.

3. Initiate a study of the mental processes involved in intelligence analysis by systems analysis to define requirements, procedures and ranking of information.

4. Establish a central organization for the advanced and development study of ADP disciplines and techniques of the various factors of field Army combat intelligence.

5. Standardize intelligence terms, place names and geographical terms in the Army and possibly for all services (a "Dictionary of Intelligence Terms").

6. Design a computer language optimal for intelligence.

7. Develop computers to process-in-parallel in combat intelligence working areas.

8. Direct its Intelligence Analyst's School to incorporate, insofar as practicable, the open-ended ideas listed in Appendix K.

EXPLANATION OF APPENDICES

The technical appendices attached are nearly verbatim records of contributions of individuals and subcommittees on the subjects noted. It was felt in the interest of comprehensiveness and unity of approach that specific contributors to each section need not be identified. In this way, the total report (reviewed by all committee members) has greater strength as a coordinated consensus. Most of the central themes contained in these appendices have been transcribed and edited into the body of this report; the appendices provide ready reference sources to technically supplement the material extracted heretofore.

APPENDIX A

FLEXIBLE SIMPLICITY IN MACHINE AIDS FOR THE 1980/90 INTELLIGENCE ANALYST

1. It appears that one could aid the intelligence analyst by the 1980/90 epoch by introducing a two part effort. The first is to develop a simple automatic system which would essentially replace the present manual system, could be fielded by the early 1980's, and could be continually developed while operational. The second part of the effort would be to perform exploratory studies to evaluate new techniques and approaches towards the solution to the several problems facing the intelligence community. This two part effort is visualized as operating in parallel with some mechanism for cross-fertilization between them.

2. It is essential to introduce within the next five years a simple but flexible automatic system to be used at division level which would replace the present manual system. This system would be such that the developed capabilities of the various manual systems are not lost when this system is introduced. It is mandatory that any new system not disrupt the present procedures to the extent that the new system would be abandoned by bewildered users.

3. Some of the features which it was felt that this system should have are:

a. The filing system should be capable of storing messages as being associated with several different descriptors.

b. The descriptors used should be capable of being defined and changed by each primary user in his system.

c. There should be several files which could be associated with each of the sub-users within a given unit. These files and descriptors should also be flexible and under control of the individual user.

d. Tho inputs to this system should be in several forms:

(1) Teletype tapes (messages received by electrical means).

(2) Keyboard and/or switch matrix.

(3) Light pen and CRT with character recognition abilities.

(4) Direct electrical connection via appropriate interfaces with TOS.

e. The outputs should also have several possible forms:

(1) CRT.

(2) Print-out.

(3) Plotters and Chart.

4. Examples of parallel efforts which must deal with new and unproven techniques in order to determine their usefulness are:

a. Study appropriate statistical evaluation methods.

b. Apply techniques of correlation and pattern analysis and recognition.

c. Study language and processing techniques towards reducing the machine oriented format requirements.

d. Study the analyst and his behavior in an attempt to formalize some of the processes which he carries out.

e. Study display techniques for application in the various operational intelligence environments.

f. It appears useful that the operational jargon and language used within the intelligence community be formalized in a dictionary as a training aid before automation aids are fielded.

5. Software Environment for Intelligence Information. One opinion of an intelligence systems analyst states that the environment required for the maintenance of intelligence information must have four primary capabilities:

a. Creation and maintenance of an integrated data base of highly variable information in a manner which permits such activities as private subsets of the data base, linking and correlation of any information in the data base, and facile handling of both formatted and unformatted information.

b. Retrieval and output processing,utilizing the integration features of the system, in a variety of forms in accordance with user specifications.

c. High level language capabilities which are easy to use and which can be used directly by the IO.

d. Detailed language capabilities which permit the construction of complex procedures, such as those required for intelligence

evaluation and interpretation, within the intelligence information environment and operating directly on the integrated intelligence data base.

6. The IO does not now appear to have adequate programming support. Existing systems, such as the PACAF/IDHS, are based on the concept of formatted files. This concept dictates that the data base be arbitrarily segmented into discrete portions which cannot be readily correlated. Furthermore, a system of files, as opposed to an integrated data base, can not provide the necessary environment within which the complex procedures needed for intelligence evaluation can be constructed. A major departure from the formatted file concept is seen as an important precondition to any system which can be expected to provide significant automated assistance to the IO.

APPENDIX B

MACHINE-AID TECHNIQUES PREDICTED
FOR THE 1980/90 INTELLIGENCE ANALYST

ASSUMPTIONS:

1. The nature of conflict, conventional or limited nuclear, will not change drastically from current doctrine. Current organization structure will remain as is.

2. The use of remote sensors and surveillance mechanisms will increase by an order of magnitude.

3. Means for sampling, recording, and forwarding sensed data will be successful regardless of the increased saturation of the electromagnetic spectrum.

4. Human observers and data samplers will have means for rapidly inputting data via verbal or mechanical methods.

5. Formatted or formal methods of data recording and transmission will be universal.

6. Several levels of security of transmission will be developed--to be used as required depending on organization level and function.

7. Message switching, store and forward, dissemination will be automated and effective at the field army's computer speed.

8. Techniques to accomplish receipt, validation, correction, screening and routing for action, file or purge will be available.

9. The computers available to the division level will be small--1'x1'x6'--to include simple IO and control gear. The computer will contain several million word memories, disc pac, photo film or equivalent, integrated circuits, fixed logic all of remove and replace nature. The IO gear will include voice-recognition, translation, computer control, computer response and vocabulary building--capabilities, coded key entry systems--i.e., stenotype or binary keyboards--communications contacts, etc. The output channels will include visual thin plate displays, verbal response, direct outputs to other computer units via communication channels.

10. Software for the computers will provide complete program support and tutorials for operational training. The support includes operating utilities such as message switching and addressing, compilers, control programs, language processors, analytical and statistical processors, data handling programs, encrypting programs, etc.

11. Sufficient developmental study and experimental evaluation have been accomplished to insure that (a) the system will perform successfully by established criteria, (b) the supporting units or systems are converted or convertible to support the new system, and (c) personnel training has been accomplished or is possible--perhaps through use of the system tutorials and examples.

12. The Tactical Operations System will be the operational system for processing of intelligence within the field army and will be considered as a base system for future research and development activities relating to automated intelligence for the field army. (See also last statement in subparagraph 5, Appendix E.)

TABLE OF TECHNIQUES

Analyst as manager or owner of a system will use and control the following types of techniques and equipment

TECHNIQUES

INPUT/OUTPUT	DATA HANDLING	ANALYTICAL	REPORTING
Voice	Text manip.	Management by exception flagging	Verbal, Written, Graphics
Keyboards: Typewriter Steno Digital	Indexing	Pattern Analysis	Action/Info Message generation
Function overlays or displays	Search	Historical analysis of data base	Photo Composition
Optical Character Readers	Purging	Error control	
Laser	Graphing	Validity & reliability analysis	
Direct Sensor	Automated file updating	Product evaluation	
Friend & Foe	Language translation & conversion	Collection Management	
Microfilm	Large Scale Storage of digital graphics & text	Conditional probability analysis	

TECHNIQUES:

The context for the following techniques discussion is provided by the above listed assumptions and table of techniques. The intent is to illustrate the notion of the analyst as the "manager" of his system. A system organized around a task concept, not one designed to process information just because it's available.

We conceive of the analyst as the master chef--who tastes, samples, creates new recipes, approves the product before delivery--while the automated functions perform the secondary tasks.

1. Input: It is hard to put a value on any of the listed techniques as each will or could be applicable for a given situation. A brief comment on each follows:

a. Voice - Voice to digital conversion will probably be practical for a limited (500 word) vocabulary in the next 5 years. Free text or language conversion in the next 15 years.

b. Keyboards - All the listed techniques are operational now and will provide the manual input means for the next few years. Certainly function keys or overlays (keyboard or CRT) provide the fastest input path for humans where the function is stylized and fixed. Stenotyped direct computer inputs can match speech speeds when dealing with large vocabularies.

c. Optical Character Readers - Certainly the fastest means for inputting printed material. As source data coding becomes more prevalent the requirement for OCR will be reduced. They will be used for building data bases from printed material. Present capability in industry is automatic microfilm indexing.

d. Graphical Inputs - Flat pack graphical read/write devices are now available. The techniques for converting line and symbol to digital form are developed. Character reading and generation are now possible for limited applications. Graphic inputs have an obvious place in the analyst's support unit.

e. Direct Sensors - The form and use of direct sensors in an army environment is impossible to predict. The intelligence system of 1980-90 must be prepared to assimilate, correlate, and use information from thousands of sensors--potentially available on a division front. Speed in handling sensor data, its interpretation and directed output to affected units will be paramount. One can envision a situation similar to electronic signal jamming that extends across the total sensory spectrum with full ECCM implications.

2. Data Handling: Much of the success of a general purpose intelligence system will depend on significant advances in data

handling. Of special importance are practical solutions in language conversion and processing. The ability to convert analog speech to digital, and the converse, implies solutions to problems of free text indexing and retrieval, automated dissemination for action, file updating and purging. General development or application of these techniques has still not been achieved. Still remaining is the primary aim of a practical language translator. Large scale storage of digital text and graphics will be possible. For example, Eastman Kodak has developed photo film with molecular response characteristics. A potential exists for storing, on an 8x10 film, up to 17K digital black and white photos or 30K digital typed pages or 60-70K digitized line drawings.

3. <u>Analytical Techniques</u>:

a. The IO will have a set of analytical support tools. He will be able to vary their controlling parameters to adjust to the situation. The primary change from today's operation is that his analysis will not be limited by the number of items of information he can scan, retain, correlate and use. Man's ability to "lump" data and handle condensed information will be enhanced by his computer systems. He will use the computer to assist in the four basic supporting processes--collection, dissemination, evaluation and action. His mode of operation will include management by exception, pattern or situation analysis, and historical comparison analysis, all accomplished via computer.

(1) Much of the routine of collection management, data store and forward, dissemination, and detection of unusual events will be accomplished automatically. The analyst will be required to monitor the process and make necessary changes in controlling parameters.

(2) The development of place or event matrixes, automatically updated, will relieve the analyst of much detail work. Historical data covering critical situations will be used to develop models of expected behavior. These models will be used to activate alarms if the expected activity deviates from established norms. Thus, the analyst will not have to maintain constant surveillance over the total tactical situation as long as the current reported actions meet the norms of the matrix model.

(3) The matrix can be used in pattern or situation analysis to develop an hypothesis concerning enemy actions. The possibility exists to compare several different event patterns against the current situation for best fit at any time. Estimates of attack, withdrawal, replenishment, holding, etc. for an enemy unit's intentions could be quickly checked.

(4) The computer will aid the analyst in historical analysis--preparing estimates of likely tactics an enemy command favors--or more general information on doctrine covering deployment, supply, POW

handling, etc. Another type of historical analysis is that intended to support evaluation of the intelligence system, itself, and its components, i.e., analysts, procedures, organization, software/hardware, etc. The proposed tools will enable the analyst and his mentors to keep better records of events and their predictors. The analyst will use his error information to effect immediate improvements--while his mentors will use this data to effect changes throughout the system.

b. The reporting means that will be available to the analyst will be numerous and are covered elsewhere in this report. A particular note on action/information message generation is appropriate. The technique of using preformatted machine generated messages that are simply reviewed and released by the analyst is not new. Many applications are in use in the military and industry today. The point is that this immediately available technique will be used more frequently. Cascading alarm systems and warning techniques utilizing computers will become routine. However, much research and operational testing will be necessary to develop and gain the analyst's confidence in these systems.

c. Error Control - The proposed tools will enable the analyst and his mentors to keep better records of events and their predictors. The analyst will use his error information in effecting immediate improvements--while his mentors will use this data to effect changes throughout the system.

d. The remaining items are of the same nature as c. above--techniques practiced by and on the intelligence function.

4. Reporting:

a. The reporting or output mechanisms are discussed above or are obvious.

b. A note on action/information message generation. The technique of using preformatted or generatable messages that are viewed and forwarded by the analyst is not new. Many applications are in use in industry today. The point is that this immediately available technique will be used more frequently in the future. Cascading alarm systems and warning techniques will require considerable refinement.

APPENDIX C

ONE COMPUTER ANALYST'S VIEW OF THE 1980/90 INTELLIGENCE ANALYST'S PROBLEMS

1. The expertise of today's intelligence analyst must be consulted in designing the automated tools which he or his future counterpart will use. His assistance only begins with helping to design the data base and to plan the information flow. Much more significant will be his aid in detailing the special techniques, "rules of thumb," and shortcuts which he has developed over the years in working with specific intelligence data. He may not know why these artifices are effective and he may not be able to guarantee that they will continue to be effective in the future. Nevertheless their past success suggests an immediate systems analysis task (to find out what's good about them) and levies a requirement on any proposed automated system (namely, that the artifices can continue to be used, at least as options). The importance of this point is that such artifices usually arise because of the detailed nature of the subject matter, rather than from some abstract theory of systems. Hence, the only efficient way for systems analysts to discover such artifices is to be told what they are by somebody already thoroughly familiar with them.

2. In applying abstract systems theories, everyone must keep the following considerations in mind.

a. The technical terms within these theories (such as "information" or "utility") have specialized meanings (explications) related to, but distinct from, their meanings in ordinary English.

b. The objectives of systems analysis (such as "optimization") are defined using these technical terms. Hence, in relating mathematical models to reality account must be taken not only of the components of the models, but also of the mathematical operations used to describe or manipulate the components.

c. Mathematical theories may guarantee that a solution to a systems analysis problem exists, may show how to find the solution in a finite number of steps, or may permit the solution to be written down explicitly (using mathematical symbols). But even given a theoretical "solution," obtaining a practical solution may necessitate examining or otherwise manipulating more combinatorial possibilities than is feasible. Typically the large number of combinatorial possibilities will have been the very problem that caused the analysis to be undertaken in the first place.

These considerations but reinforce the earlier conclusion that the intelligence analyst must be involved in the systems analysis, although not as a systems analyst.

3. Systems analysts should study, describe, and to some extent automate what the intelligence analyst does already. This is largely an empirical task, with some data processing thrown in. But they should perform also a normative task which may be of much greater importance in the long run. They should compare what an intelligence analyst does with what in some sense he "should" do, or with some upper bound on what is the "best" that he possibly could do. Human factors are relevant to the normative task, but of more direct concern are the mathematical sciences of system optimization and the physical sciences concerned with potential hardware capabilities.

4. The training and experience of systems analysts is specifically directed towards performing this sort of normative task. The intelligence analyst is unlikely to be sufficiently familiar with the multitude of aids potentially available to be able to judge which ones are most suited to his needs. But he labors under other handicaps as well. His very closeness to his subject matter, though invaluable in finding practical shortcuts and in judging which aspects are most important, may hinder him from finding new techniques. Various types of fixation--such as semantic fixation, which makes it difficult to see familiar objects from a novel point of view, and fixation in method--are problems here. The problems of fixation become most acute when the analyst has to work under pressure for long periods of time, as is often the case. Systems analysts should listen carefully to the intelligence analyst. They should carefully observe him in action. They should find out what he does now and how he thinks it can be improved. But they must also contribute their own ideas and experience. Above all, they should formulate and quantify the results of their investigation in mathematical models which both they and the intelligence analyst can agree are appropriate and meaningful.

5. Another problem with which the systems analysts can help is the conservatism and inflexibility of organizations which have been doing something in a given way for a long period of time. A historical example may illustrate this point. The ancient Egyptians preferred to express any proper fraction as a sum of reciprocals of natural numbers (perhaps including also the fraction 2/3 as a term in sum). Thus .08, or 8%, or 2/25 would be expressed "most simply" (to their way of thinking) as 1/15 + 1/75. They had no notation for decimal fractions, or percentages, or for fractions in general, except of the sort described. Nevertheless they worked out complicated but effective methods for adding, subtracting,multiplying, and dividing fractions expressed in this form and they used these methods for centuries upon centuries. For us it is natural to ask why something akin to our own methods was not discovered and promulgated. We can only guess at the answer. But the same conservative forces, whatever they are, may be at work in some of our own organizations. The systems analyst must be prepared to help pave the way for desirable changes by explaining carefully what the proposed changes and

concomitant benefits are and by considering how the changes may be introduced with the least upset to the existing system.

6. How can the Army intelligence analyst get together with some systems analysts? And how can he decide which systems analysts he wants to get together with? One obvious way is for him to have a look at some systems analysis or operations research reports which seem to relate to his area of interest. Then he might read carefully the resumés of scientists who would be available to talk with him. Putting the two together, the reports might suggest some questions he wanted to ask and the resumés might suggest some people of whom it would be reasonable to ask them. Depending on the answers obtained some sort of working relationship might be expected to develop. Even a question as broad as "How can systems analysis/ operations research help me in my work?" would do as an opening, although the man who asks it will understand the answer much better if he has had time to look through the literature in advance.

7. Joint participation of intelligence and systems analysts in a small scale exercise or game would be an excellent way for each to learn something about the other's modus operandi. The exercise should be realistic in everything except the pressure of time, since one of the objectives of the exercise would be to avoid the problems of fixation mentioned above. Either a fictional or a historical scenario could be used for the exercise; probably a sanitized version of a historical scenario would be the easiest way of providing a wealth of realistic, if not completely factual, detail.

8. A complaint frequently heard at the conference was that a great deal of research was wasted because funds were cut off before the end product was achieved, because people unfamiliar with the research had had to reproduce "known" results independently, or because reports were not readily enough available or widely enough read. It was sometimes proposed to alleviate these problems by making some change in the organizational structure. It may be that the problem is not so bad as it was painted, however, and that the proposed solution would not be so useful as might be hoped. Here are some points to consider in this connection.

a. First, it may be aruged that a nation's intellectual wealth is to be measured less by the amount of information contained on the shelves of its libraries than by the capabilities of its inhabitants. In the extreme, all the information in the world is of no avail to people incapable of using it, although capable people can accomplish much even without a library. Carrying out research, even unsuccessful research, trains the people involved. They take this training with them to their next assignment. Ultimately their experience becomes a part of our culture and our culture is the richer for it. Agreed this is a poor substitute for a job carried to completion in the first place. Still, when one considers all the research throughout the country which for one reason or another is prematurely terminated, the cumulative effect of such training is considerable.

b. Secondly, even when the primary report is hardly ever seen by anyone not immediately associated with the research, the chances are good that any significant improvements in the state of the art resulting from the research will be published separately in an appropriate scientific journal. If the journal article itself is less widely read than it should be, that is a separate problem where internal reorganization will be of little help.

c. Thirdly, people who derive results independently usually have a more thorough understanding of them than those who simply read somebody else's derivation. Moreover when several different groups of people derive the same results independently chances are that the results are timely and of importance, and therefore worth understanding thoroughly. Here again the situation is not ideal, but neither is it so bad as it appears at first glance. And, scrutinized closely, the "same" results are often obtained differently and with different corollaries, so that in the end everybody benefits from the separate developments.

d. Finally, the problem of unread reports can be greatly aided by people knowing what one another's interests are and passing on bibliographical references--better yet, the reports themselves--as appropriate. To do this requires enough technical competence to understand what is in a report and what other people's technical interests are. Managers with a responsibility to keep informed of collateral research activities have an excellent opportunity to pass on such information. Surely they can be encouraged to do so within the framework of existing organizations. It is not clear how a change in organizational structure in itself would help this particular problem.

APPENDIX D

SOME SUGGESTED PLANNING ASPECTS
FOR PROVIDING AIDS TO THE 1980/90 INTELLIGENCE ANALYST

1. Problem Definition. It is necessary to establish a starting point and a conceptual framework to guide the development of techniques which will be long-range R&D and involve many personnel from different organizations having differing backgrounds and expertise. The area of military intelligence and the task domain of the future analyst are so broad and so diverse that an attempt to generate a simple description of the intelligence problem or the intelligence analyst may be unremunerative. A complex set of descriptions of the problem/application domain are required. These will be function-task oriented descriptive as well as information content input and output descriptive. Little can be found on documenting which intelligence indicators probabilistically relate to which tactical operations. This knowledge is possessed in the collective heads of those who have performed intelligence analysis. It appears that the aforementioned information is critical to an adequate description of the machine-application domain. This information is what the designers must know in postulating and developing techniques to assist him. It should be possible to select a group of expert analysts representing a wide range of backgrounds and experiences and to elicit their judgments regarding the aforementioned relationships. This may be a difficult task and time consuming, but a rewarding task. There are scientific methods available today for eliciting and analyzing such judgmental data. Such a study may be a necessary prerequisite to establishing an effective technical attack at the problem area.

2. Physical environment and context within which techniques can be developed, tested and integrated. A well-equipped, specialized R&D laboratory devoted to the R&D of intelligence processing techniques is required. Current Army laboratories seem to be either discipline oriented (engineering or psychology) or technique oriented (display techniques). Neither of these types provide the answer for successes in machine application. Development seems to come from multi-discipline technical teams and the solutions seem to involve sets of techniques and devices which we heretofore developed separately and considered to be unrelated in a practical sense. The ideal laboratory for this task should be outside the operational environment physically or should be at least outside the control of an operational intelligence organization so that it may have the freedom to pursue ideas and techniques which are likely not to be productive for a long period of time--perhaps 10-15 years. However, this specialized laboratory should not be so removed that the goal or the application is diluted and the only techniques for techniques sake are pursued. The

laboratory should be under control of the military and specifically under the direction of military personnel with extensive background in sophisticated tactical intelligence. It should be staffed by military and civilian technical personnel with the widest spectrum of technical skills. It should have the latest computer and related hardware and software. It should also have an intelligence data base as well as typical and meaningful intelligence analysis and production problems to provide proper orientation to the technical personnel both for insuring efficiency of technique development as well as for operationally (military) testing any products which result. This laboratory should also have close ties to the operational intelligence production organizations and to the training elements so that: (1) users can be put in touch with evolving solutions at an early stage; and (2) eventual users, not part of the R&D process, can be used as test subjects to empirically check out proposed solutions.

3. Technical areas for concentration of R&D. The 1980/90 time frame will involve concepts and techniques which go considerably beyond the document storage and retrieval capability which we have today. As a frame of reference, in the near future we will have on-line remote-access time-shared computer environments with considerable flexibility in hardware and software. Within such a context we need to develop techniques for the analyst to:

a. Handle fragmentary unformatted data, i.e., natural language text. This means that we need to concentrate effort on automatic indexing, classification, extraction, syntactic and semantic analysis, and correlation as well as computer aided language translation.

b. There is a need to look at useful methods for representing natural language text. Much of the searching and manipulation of a natural language text data base will involve the retrieval, aggregation, and representation of surrogates of the text units. For example, retrieval and display of message citations might be useful to analysts for purposes of formulating and checking out hypotheses.

c. There is a need for a strong human factor effort required, vis-a-vis how to display data most productively to an analyst.

APPENDIX E

SOME THEORETICAL CONSIDERATIONS IN AUTOMATION OF INTELLIGENCE DATA

1. Approach to the problem. There are several possible approaches to the problem. One of those, perhaps more suited for far distant planning and application around 1990, is to project present trends to that year. This avenue will be taken in the following pages.

2. Automation possibilities for second and third generation TOS systems.

a. To provide a feedback to the surveillance systems in order to guarantee proper and optimal employment of the surveillance systems. This enriches or reflects on the intelligence input data.

b. To observe deviation from a tendency towards sameness in the information contained in the identifiers.

c. To improve an automated English and foreign language readings.

d. To simulate the intuitive or meta physical processes of the analyst. (Some of the problems and a possible approach to their solutions is given below and in Appendix F.)

3. Pattern recognition.

In the future, more sophisticated filters which can replenish an incomplete pattern will be necessary. These procedures are being used and further developed now in industry and universities in order to restore smudged areas in two-dimensional patterns such as fingerprints or in filling in long gaps in particle tracks in bubble chamber photographs, etc.

For an example of pattern recognition, the size and shear normalization representing a simplification of the pattern of troop concentrations in space and time on a long battle front (with negligible depth) to a two-dimensional problem-one space and one time coordinate, or two space coordinates) can be carried out even today rather elegantly and satisfactorily by applying a linear transformation to transform the 2x2 moment matrix of the pattern into the identity matrix.

Application of higher order auto- and cross-correlation functions can be foreseen; however, in military application these must be applied to intelligence problems where we have to investigate patterns which differ in more than just translation. In these cases

the first order auto-correlation function, defined in one-dimension by

$$\Phi_x^1(\tau) = \int x(t)x(t+\tau)dt$$

may not suffice.

The higher order auto-correlation function, for example, can be shown to be unique, for $n \geq 2$ (n=dimension) except for translation:

$$\Phi_x^n(\bar{\tau}_1, \bar{\tau}_2, \ldots, \bar{\tau}_n)$$

$$= \int x(\bar{t})x(\bar{t}+\bar{\tau}_1)x(\bar{t}+\bar{\tau}_2) \ldots x(\bar{t}+\bar{\tau}_n).dt$$

If the inner product is used for classification in the auto-correlation space, the immense amount of computation to obtain these transforms for large n can already today be reduced through the relation

$$\int \Phi_x^n \Phi_y^n d\bar{\tau}_1 d\bar{\tau}_2, \ldots, d\bar{\tau}_n = \int \left[\int x(\bar{t})y(\bar{t}+\bar{\tau}) \right]^{n+1} d\bar{\tau}$$

This simple correlation technique often seems to be adequate for classification in the very high dimensional spaces. A digital computer effort should therefore be initiated in order to develop the programs and consequently the necessary hardware (possibly analog) for the future army intelligence needs.

One considerable obstacle in the gigantic surveillance task of the future will be to formulate the criteria for "good" measurements for various pattern recognition tasks. This is true today because the measurements favored by different investigators have so far never been compared on the same data set, hence objective evaluation of the merits of the different systems is practically non-existent. Again a unified computer program effort should be undertaken to investigate and compare the different intuitive measurements, some of which are:

- topological information
- stroke information
- neighborhood operations
- format extraction
- texture information

Heuristic methods as the ones above are largely responsible for almost all of the pattern recognition devices which have been incorporated in practical systems to date. A more rational approach can only be foreseen after the comparison suggested above has been carried out and if an underlying common logical structure for a unique pattern recognition procedure may then be discovered.

The understanding of these facts will be vital for the future army and its intelligence apparatus where, due to the obvious intelligence data increase, millions of intelligence information data will be accumulated and will have to be compared. In order to sort them out, i.e., separate the vital parts of the information from redundant and false information, a most refined pattern recognition process will be a minimum requirement.

In order to make pattern recognition more cohesive discipline than it is today (and only as a cohesive entity will it constructively aid the field of intelligence interpretation) the vast collection of highly varied problems of which pattern recognition consists will have to be uniformized and more rationally rather than heuristically founded.

4. Decision Processes:

It can be foreseen that in intelligence analysis in the nineties more than one million bits of information (for instance, one million sentences representing intelligence information) will have to be placed and stored in a computer which should then, after the proper identifiers have been placed upon the data, be ready for quick data retrieval. Since each identifier will still contain a considerable amount (in the ten thousands) of sentences, the task of the intelligence analyst will become unsurmountable. This is similar to a literature survey of a certain field, where one often finds (especially those who perform the survey and who also are creative in the field) that more than, say, eighty percent of the information is just mere or even bad duplication of the more original works and that sifting-out these duplications remains the most urgent problem. Certain studies pertaining to this sifting-out process have been done in the past. They use statistical and probability methods to search for a certain combination of words in a text with which they derive an automated abstract or summary. More work in this field is yet required, however.

For possible and also efficient application of such processes to intelligence data, one can conceive that after the work, which places the data in the proper identifier, has been performed, an automated process should then be available which identifies further what part of the information is redundant (or the same). In this way, we could divide the data within the specific identifier into two parts. Part A and Part B, where, say, Part A contains everything

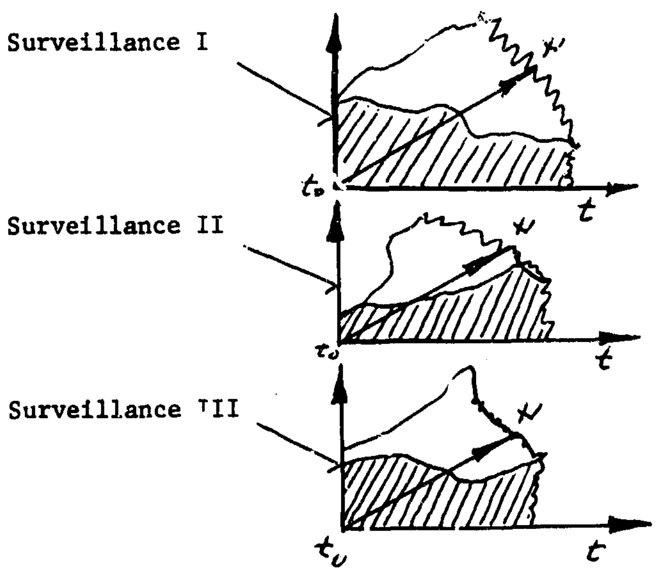
contained in Part B and more. Thus, Part B. of the information can be eliminated.

In order to execute such a program, it will be necessary to have a dictionary, composed by intelligence officers themselves, containing all the terminology which they use in intelligence work related to a field army in combat. On the basis of such a dictionary, acknowledged by all concerned, software consisting of programs, algorithms, etc. can then be developed to deal with this vital aspect of information explosion. The suggestions above are only part of the decision process related to intelligence data, but probably are the most vital parts to make future intelligence analysis feasible.

5. Coordinating the individual surveillance systems. (a possible approach)

This coordination can be performed in several ways. One which comes immediately to mind is the use of auto and cross-correlation in three or possibly in two dimensions. Consider the following situation:

Let us assume that we have three surveillance systems to consider. In time and space scale, they look like this:



where the x-axis means x and y.

Using a three-dimensional programmed auto and cross-correlation (or possibly a two-dimensional program) process, we can by computerizing (programming) the three-dimensional surveillance

surfaces, develop the software techniques in order to establish a marginal domain where the most coherence occurs and hence give a warning to the IO to look deeper into the problems. There are two-dimensional auto and cross-correlation programs in existance. Moreover, the density of the data necessary for the three-dimensional surveillance surfaces can be established so that meaningful correlation results can be obtained.

This increased demand on certain surveillance systems in terms of greater frequency and better distribution of data can be considered as a feedback which enables a better rationale of and the how, where, and when a surveillance system should be employed. Automated correlation processes would permit then a better utilization of surveillance systems and hence a more improved intelligence data input procedure.

The data bank will be no problem as regards to size and convenience. Recent developments at Lockheed, for example,indicate that one can today with new devices store in the space of a cubic foot more data than some of the largest present day IBM computers can hold. This means that storing the ever-increasing number of data in the future for field army combat intelligence should be a smooth operation.

Most important for the intelligence task in the future will be the study of the interaction between input data, storage and data retrieval. Here the need for continuous flow diagrams, depicting the dynamics of these three processes will become evident. Before a complete automated system, geared towards optimum information flow can be conceived however, it may be necessary to supplement the three operations above by display devices with memory facility such that any past flow interaction can be studied and possible precursors of future flow features may become evident. This will serve to handle efficiently time decay or saturation type problems.

The TOS system which will be installed and available by 1975 should form a basis on which to study the interaction problem between data input, storage and retrieval.

6. Some of the new Hardware and Software Concepts.

a. Direct hook-up of surveillance devices to automated information processing equipment.

b. Display techniques permitting the study of dynamic interaction between data input-storage-retrieval.

c. Screening programs applied to data in identifiers in order to provide new output format for use for analysts.

d. Filters which can replenish an incomplete pattern applicable to surveillance and intelligence analysis.

e. Programmed correlation techniques to further surveillance task and complement intelligence analysis.

7. Summary.

While there may be much to conjecture as regards to intelligence in the 90's, it may eventually turn out that intelligence in the 90's may constitute something completely different than what we understand it to be today. As an example, consider the following sequence of possible developments.

A large amount of intelligence information today relates also to information obtained at night. The recent development of operational night vision devices and their ever-increasing refinement and variety demands on our side, particularly those who carry the responsibility of formulating, analyzing, and developing new advanced concepts, the development of counter-measure devices and to at least anticipate means of counter-counter-measures. This is eminent when we give the prospective enemy the benefit of the doubt, namely, of being in the same stage of development as we are and the adherence to the paramount philosophy that the best way of preventing a war is to be always superior in spirit, manpower and armament. Assuming then the existence of counter-measures to night vision, for example, in both our and the enemy hands, the knowledge of the presence of troops, gun emplacements, tanks, etc. may virtually be non-existent. But it is this information today which forms one of the most important parts of the Field Combat Intelligence picture.

8. References.

"Automatic Full Text Indexing and Searching System" by J. H. Williams and M. P. Perriens, IBM Report. IBM Federal Systems Division, Gathersburg, Md.

"State of the Art in Pattern Recognition" by George Nagy, Proceedings of the IEEE, Vol. 56, No. 5, May 1968.

APPENDIX F

PRACTICAL CONSTRAINTS IN SEEKING FUTURE AUTOMATION OF ARMY TACTICAL INTELLIGENCE DATA PROCESSING

1. Approach to the Problem.

The problem may be addressed along two lines. One,the present intelligence data system can be materially aided in the near future using only presently available hardware and techniques. Two, considering the purpose of one completed, to build and expand the system based upon findings of one and also projected or prophetized hardware and software.

2. Areas of Initial Interest Requiring Data.

a. The analyst, who is in fact the manager of the system, utilized bits of data to form an opinion or analysis of intent. His thought processes and logic system has not been reduced to a recognizable pattern. His choice of factors (descriptors?) influencing his logic is not clearly defined and varies analyst to analyst. His past experience has great influence but is not formally cataloged other than working files of data he considers important. Other analysts on the same job but on different shifts utilize the same data base but maintain a differing file since their logic requires differing factors. Of course, many of the factors will be duplicated. Study of various analysts should disclose the factors which show commonality and should give a picture or an insight into the logic process. This can be factor analysis with cluster recognition or a quasi multiple regression using weighted judgement values, etc. War games may provide a source of experimental data. These games conducted under rules adding bits of intelligence to players separated from the complete data package should give some insight into the effect incremental data lends to decision processes. TARS-75 (Tactical Reconnaissance and Surveillance 1975) may also be a fruitful source of descriptors.

b. While TOS (Tactical Operations System) has estimates of traffic flow and count, input format and language, and desired outputs, further data needs to be studied in actual use. The experimental TOS operation will provide many of these answers which in turn would dictate the system capacity needed which could be projected to future time frames.

c. The analyst in effect acts as a censor or filter of the input data. Data is required to determine if the censoring was correct or the decision to forward to higher headquarters in a censored and/or refined manner was also justified.

d. While analysts presumably go through the same training and utilize the same manuals, etc., further information is needed as to:

(1) New training program requirements.

(2) Degree of acceptance by already trained analysts.

(3) Time frame of training necessary to coincide with equipment.

3. Automation of Present Intelligence System Utilizing Present Day Hardware.

a. Since TOS is now only undergoing an experimental field test using leased commercial equipment, its introduction would be probably early 1974. Thus, we may consider the 1970-1980 time frame merely amenable to proferring automated aid to the analyst. This would consist of providing input and retrieval capability with descriptors as desired and selected by the analyst.

b. Unless input can be either formalized format or automatic (i.e. teletype, etc.), the analyst will gain little over his manual system. A CRT and light pen to designate descriptors would be of immediate value.

c. Internal programming at first will be rather simple minded and merely for filing and retrieval of information by descriptor with simple arithmetic procedures if desired.

d. Output would be printed or displayed on CRT and be amenable to transmittal to higher or lateral compatible sources. Many of the intelligence publications or summaries should be capable of being machine handled.

e. As the analyst became acquainted with the capabilities, new programs would be added, such as compartmentalized data with warning capability with pre-set levels entered by the analyst, programmed printouts in graphical (geographical) form, etc. As time progressed, elementary trial programs to provide estimates could be compared to the analyst's conjecture and gradually improved. (This would not be at all locations but as a R&D effort.)

f. Some thought was provoked concerning security. Any system, manual or automated, has similar dangers. No revolutionary concept concerning security would be required. In fact, an automated system could reduce the danger of loss of information through capture being susceptable to immediate erasure of data with only printed output to be put to the incendiary torch. Usual electronic security should be able to cover transmission security.

g. Systems could be "preloaded" with data for areas, situation, etc. This preloading and retention would materially assist in smooth transferral of responsibility when personnel changes occur. These "packages" could be prepared for all eventualities and geographical locations, i.e., low intensity warfare "Lower Slobovia," high intensity warfare "Upper Atlantus," etc. and thus give the analysis a running start. Note that a complete global set of pre-"packages" is practically a strategic data base.

h. All of the above is neither new or novel but is entirely within the province of TOS as presently envisaged or as currently practiced on test.

4. Automation Possibilities to Enhance or Supplant TOS 1980-?.

a. Further development of pattern recognition (cluster analysis?) and use can be made available as the analysts become acclimated to or trained on ADP equipment. Pattern recognition is being done mentally now by the analyst from their explanation of their duties; but their intuitive or metaphysical processes have not been described other than in one or two trial computer programs. These programs have competed successfully with analysts when fed "data" piecemeal with decisions after each submission. (The human tended to conservatism.)

b. The aggregation of data while feasible today could be greatly improved through direct visual input mechanisms and "Real English" computer capability. Thus, material in any format and in any language machine translatable into English could be integrated by simple Real English commands. A further projection would make the input and output amenable to spoken English; however, this is in one of the much later time frames. Error correction and validation processes are tacitly assumed in all cases discussed. As the data were inputted some degree of confidence or reliability could be assigned by the analyst as well as the introduction into various decision equations or models for immediate analysis. Decision to erase or add to post data can be made at entry or by the program. These decisions await further study of the logic and also a successful model.

c. To identify time dependent data implies a successful model. This is entirely plausible and can be done; but much data for a prediction model that is tractible and about which statements having confidence intervals can be made. Of course, time dependence includes time decay. One distinct possibility allows "warning" or, say, "quality control" limits established by the analyst (model?) can be placed on these trends. For example, one limit would be a level at which a certain indicator discloses the enemy could defeat the analyst forces. Surely an approach to this limit should give a warning.

Conversely, a lower limit would establish either a minimal threat or even more seriously the need for an increase in surveillance that would and could either reinforce this decision or call for a new decision. Wherever a machine decision is discussed, this merely infers a "guesstimate" to be further considered, digested, and then given credulence only by a human analyst. The system is not to replace, but to aid, augment and assist the human. Regardless of computer technology, the learning process will still be guided by the programmer.

d. The use of statistics and mathematical models is implicit in almost all of the discussion of decision, limits, etc. Only the filing and retrieval are excluded as "bookkeeping." But even in this, statistics may be used to determine the proper "box" or format.

e. The teaching of the computer is considered to be the application in reverse of the learning process of the analyst and the researcher of the results of the system growth through the manual file to automated file to decision making sequence of system development.

5. Projections and Recommendations.

a. Volumes and rates of data flow need a pilot study.

b. The thought and logic processes of the analyst should be studied and modeled concommitant with TOS field experiment.

c. While display has been only briefly touched upon, the user, i.e., the commander, in the final analysis needs his requirements included. These need study to see if compatible or duplicating those of the analyst. The hardware and software concepts considered include:

(1) Display Techniques - Pilot Study.

(2) Output Format and Publications (i.e., is TOS the target or are new concepts after TOS needed).

(3) Input-Voice-facsimile, TV, photographs, direct surveillance sensors, portable keyboard, radio, etc., all need study and thought as to user's requirements.

(4) Output-Similar to input methods, direct output laterally and vertically, "warning" display all need study as in (3) above.

(5) Internal programming must wait user requirements. Various capabilities have been discussed in greater detail above.

(6) Many specific decision approaches exist. A fertile field for further investigation includes the behavioral sciences and the medical sciences. After all, the analyst is similar to the

psychologist and to the medical doctor who observes subjects, takes some measurements, asks some questions and then makes a diagnosis and/or prognosis. He then observes the result and adds this to his experience file for recall at a later date. Many of these processes are now being translated to ADP and suggest possible intelligence reports.

d. All of the above illustrate the need for further work but also substantiate the amenability of automation to intelligence processing. While philosophical in approach, the discussion highlights some of the more practical paths for immediate results that can be projected. For example, photography can be extended to holography, CRT display to liquid crystal emulsion electronic display (remain visible when power removed), static display to "instant replay"-split screen, light pen and CRT to laser and film, face to face briefings to recorded briefings with instant access to briefer by electronic means, surveillance sensor raw data to signature sensor data, recording voice traffic for translation to automatic translation and entry, independent system to system including TACFIRE and other system direct input.

APPENDIX G

ANNOTATED BIBLIOGRAPHY BY MAJOR SUBJECT

SOFTWARE - DATA PROCESSING STANDARDS

Reprint from "Computers and Automation," 1963 and 1964, "Brandon Applied Systems, Inc.," 30 E. 42d St., N. Y., N. Y., 10017, supplies additional copies on request. Strictly commercial but a standard would help in a field army computer system.

"Design of Information Management Systems," Auerbach, October 1966. Deals with system program philosophy, programs that automatically collect more and retrieve, search and present real-time and stored data. Gives general understanding denied in setting up requirements for the computer centers program structure.

"File Organization and Data Management," Winker and Sable, Auerbach, April 1967. Presents the techniques and organization, maintenance and search for machine files, managing large data bases and present data to users not computer proficient.

"Multi-Queues with Changeover Times," Eisenberg, Ted. Report #35, OPN. Res Center, MIT, April 1968. The integrated army computer system will work in a time-sharing mode with some programs being run only occasionally. Oncoming theory may come into the picture.

"Classification of Alphabetic Letters by Characteristic Loci," Glucksmann, OAR Research Review #3, March 1968. Character recognition equipment will not be used extensively since direct data input will be readily available; such readers will be useful in connection with other than English and possible Cyrillic alphabets or ideographs, where the method described could be used if properly modified.

"Natural Language Processing," Simmons, Datamation, June 1966, p. 61. Popular Science article on language translation, composition, etc.

"Research Report on Linguistics," 4th Quarterly Program Report, Feb 1964. Contract DA-36-039-AMC-02162(E), University of Texas. Not more than a program report.

"Heuristic Derivation Seeker for Uniform Prefix Languages," Chroust, University of Pennsylvania, 1965. Describes a heuristic procedure to the problems of theories provisy by machine. Has limited interest in problem at hand.

"Learning with a Lack of Prior Data," Shubert, Stanford University, December 1967, Center for Systems Research, Technical Report No. 6151-4,

Contract Nonr, 225 (P3), Nr 373-360. Describes a decision maker program which makes a sequence of decisions from a given set of decisions in a number of steps on a learn-as-you-go basis. May be useful to criticize decisions made by intelligence officer.

"A Technique for Probability Assignment in Decision Analysis," Lamb, March 1963, g.e. 67 MAL 02. Introduces a probability density function well, more to decision making.

"Combining Overlapping Information," Zeckhauser, Rand Co., July 1968. Attacks the problem that is encountered when an attempt is made to pool the probability estimates of a number of individuals with some separate and some common experience into a jointly assessed probability distribution.

"Estimating Cost Uncertainty Using Monte Carlo Techniques," Dienemann, Rand Memo RM-4854, PR Jan 1966. This memo is part of a continuing research effort in "estimating costs of future weapons systems."

"Replacement Rules for Partially Observable Equipment," Ray, Tech Report #37, November 1967, Contract Nonr, 3963 (06); Nr 276-004, DSR 79493, MIT Opn Res Cen. Rules for replacement are established. Parameters appearing in the rules are determined by algorithums developed in this study.

"Link Structured Retrieval: Prototype System Design" by Richard I. Polis, The Mitre Corporation, November 1968. This report defines preliminary specifications for a LSR system to satisfy the known information and data management needs of certain classes of users. It is implied that such a system must be quite complex in its realization, primarily because of the need to dynamically access a deeply structured data conglomerate.

HARDWARE - COMPUTERS - GENERAL AND SPECIFIC

Information processing systems for the field army (State of the Computer Art) FOUO by H. T. Darracott. Reviews standard computer hardware. Exotic devices are covered. Gives a forecast of the state of the art of computer technology plus a program for achieving advancements through 1975.

MIL DATA STUDY, Report #4, October 1964 by NCR, Contract #DA-36-039 AMC-03268(E), NCR Report #24-4A; Final Report # Vol 1 and 2 (Honewell), Contract DA-36-039 AMC-03275(E); Final Report, Contract DA-36-039 AMC-03276(E). All these reports are very good for their timeframe. Promising approaches were described and some of them are still promising.

Philosophy of handling high-speed data, 68-703, 1968, Instrument Society of America ISA Conference presentation. An account on inputting large amounts of data.

The capabilities of remote data processing, Data Management Magazine, November 1965, January 1966, March 1966. Explains principles involved and applications. Emphasis in the intelligence system will probably be more on the central data bank because computers will become so small eventually, that the remote station will have one, but data storage may not keep pace.

State-of-the-Art of information technology in the US, Auerbach, presented to Netherlands EDP Research Institute, October 27, 1965. Business oriented, some good points are made which may be useful in the system envisioned.

85,000 computers by 1975, Reprint from "Administrative Management," June 1966, extrapolation of technology and use of computers.

Computer Analysis and Thruput Evaluation, "Computers and Automation," January and February 1966. Not so much for building up a concept but for fitting a computer into it.

"Combat Service Support System," "Signal,", May 1968, p42. A description of one of the three computer systems being studied by ADSAF at Ft Belvoir.

Setting characteristics for fourth generation computer systems, "Computer Design," August, September, October 1968. This series of articles deals with software, hardware and the impact of large scale integration.

Laser addressable Manganese, Bismuth Film: Key element in a high-density optical memory, "Lasers Focus," March 1968, p18. The bulk, mass or even the working memory of the future computer may well be an optical one using three-color switchable lasers and photochromic film.

Army tactical data systems, Albert A. Crawford, Jr., Telecommunications, September 1968, p23, gives good panorama of present Army field computer and data communication experiments.

Central Data System Concepts for Spacecraft Data Management, Finnel, Egger, Bello, Tel-communications, June 1968, p29.

Report on a spaceborne TM system including the gamut from sensor to transmitter input. May be useful for determining the degree of possible computer proliferation in the Army.

"Project ANSRS (Analysts Support and Research System)," DIA (ATTN: DIARD). Descriptions of military intelligence analytical processes.

DATA COMMUNICATION

"R&D Objectives for the Future Defense Communications System," Walsh, Signal, September 1968, p.6 ff. This system is secret so only a very general account could be given. Some data can possibly be used to plan the field army so as to be compatible with this system.

"A Study of Design Philosophy and Implementation for the Control of Tactical Digital Switching Centrals in the Future Field Army," Sylvania Electronics Systems, East 31, September 1964, Contract DA-28-043-AMC-00187(E). This is a preliminary report on a switching network, controlled by a computer. If such a system will be implemented, the intelligence system has to operate within this network's constraints. We may have to have an input to the planning with regard to channel capacity, channel availability and station accessibility.

"Examination of Several Techniques of Data Exchange for Autodin," Auerbach, May 1964, Tech Report 1145-TR-20 for Defense Communications Agency, Contract SD-194. Evaluation of four error-detecting codes for digital data transfer reliability.

"Western Union's Participation in the Telecommunications Field as it Relates to the Transmission of Data and Use of Computers," Benthine, April 1967. Gives background on teletype and other digital data transmission and switching systems up to 48 KC.

"Data Transmission, The Art of Moving Information," IEEE Spectrum, January 1965, p65. Basics of data transmission.

"Overflow Storage in a Store-and-Forward System," Conference paper, Shafritz and Rose, Auerbach Corp. Title is self-explanatory. Overflow certainly cannot be allowed in the system under consideration, but the paper only considers remedy at the central switching stations; in our case, the central could send a "busy signal" and the remote station would queu up the messages.

SENSORS

"Intrusion Detector Now Available for Plant Security," techniques newsletter by Barnes Eng Co., Spring 1968. Generates an electrical signal when input changes with a time interval to two infrared sensors.

"Recognizable Photographic Images Recorded Over Range of 7-1/2 Miles," Laser focus, April 1968, p12.

HUMAN LANGUAGE TRANSLATION

Computer Linguistics, OAR Research Review #4, April 1968, p6. Outlines difficulties encountered in natural language programming. Not really pertinent.

Programming by questionnaire, Auxiliary programs, RAND Memo RM-5689-PR, August 1968. This is a method to generate a program, instead of writing it in FORTRAN, e.g., sort of pertinent to intelligence analysis.

Linguistics Research Center, University of Texa , Symposium on the current status of research, Grant NSF GN-54, 6 November 1963. An older account on automatic language translation by the use of an intermediate (interlingual) language.

MIT, Verbal and graphic language for the AED System, MIT, Project MAC, 1964, MAC-TR-4. Computer language.

Mechanical translation, Vol. 8, #2, February 1965, e.g. sentence-for-sentence translation: an example, p14. This magazine may very well be the best source for mechanized translation concepts.

JCS publication #12 of current issue.

DISPLAY

"Information Display and Data Acquisition Systems." Presented at the 1968 ISA Annual Conference and Exhibit, October 1968. Summary on computer generated display only.

"Verbal and Graphical Language for the AED Systems; A Program Report," by D. T. Ross, 1964, Project MAC, MAC-TR-4, MIT. Concerns programming with and for a graphic display.

"Data Display Programming," many contributors, NASA Contractor Report NASA-CR-1107. Gives insight on methods used, flow charts, data. Good bibliography.

"A New Type of Display - Photochromic," Winiger, The Electronic Engineer, June 1968, p13. Gives a short account on the use of photochronic material in displays with electron beam excitation. Such materials are in the labs now for a very long time, but now finally results are showing up.

"70/752 Video Data Terminal," propaganda by RCA. Shows CRT - keyboard combination terminal for alphamerics only.

APPENDIX H

LIST OF ATTENDEES (AND DISTRIBUTION LIST)

NAME	ORGANIZATION
Captain Robert M. Glorioso Mr. Roy A. Mattson	US Army Electronics Command
Mr. Richard I. Polis	MITRE Corporation
Mr. Hawley A. Blanchard	Stanford Research Institute
Mr. Peter K. Luster	Kettelle Associates, Inc.
Mr. Robert D. Lunsford	Federal Systems Lab, IBM
Mr. Roger Weber Mr. Al DeLucia	USAF Rome Air Development Center
Mr. John Waite	Crypt Analytic Computer Sciences,Inc.
Mr. Leroy Aarons	Chief of Naval Operations (Dev)
Mr. Marvin Denicoff	Office of Naval Research
Mr. W. H. Wood	CIAB, OACSI, DA
Mr. Will C. Rowland	USACDCINTA
LTC Kenneth Wu Mr. Douglas M. Hylton Lt. John L. James Lt. Stephen B. Tallman	USA Intelligence School
Major David O. Goodwin Mr. William C. Mulraney	Defense Intelligence Agency
Mr. T. L. Eliott	Automated Data Field Systems Command
Mr. Y. M. Farmer	OACSI, DA
Major Peter Bunevich	Army Research Office
Mr. Eric H. Schuetze Dr. J. Martinek, R. Schnell and other Selected Scientists	USA Advanced Materiel Concepts Agency

APPENDIX I

EXPLANATION OF ABBREVIATIONS

AN/TSQ-91 - radar set

ARO - Army Research Office

CDC - Combat Developments Command

CRT - Cathode Ray Tube

DA - Department of the Army

FAA - Federal Aviation Administration

FADAC - Field Artillery Data Computer

407L - airforce/airborne system

473L - airforce/airborne system

IDHS - Intelligence Data Handling System

NASA - National Aeronautics and Space Administration

NORAD - North American Air Defense Command

PACAF - Pacific Air Forces

SAC - Strategic Air Command

SNAP - power system

TACFIRE - Tactical Fire Direction Center

TOS - Tactical Operations System

USACDCINTA - US Army Combat Developments Command Intelligence Agency

APPENDIX J

SELECTED EXTRACT OF COORDINATION COMMENTS

Most coordination comments received were incorporated directly into the text of the report. The following comments, however, which were received from a senior Army scientist, were felt to be sufficiently broad, worthwhile and cogent so as to warrant their inclusion here as an informational appendix:

"a. The participants of this symposium are obviously skilled in existing digital computational hardware and software and they seem to imply that the future developments in the automated Army intelligence will constitute merely an extrapolation of their own present knowledge. It seems to me that this view is altogether not warranted. The methods of computation known today are very inefficient from the information theoretical point of view insofar as they are almost entirely sequential rather than parallel. Human mind processes information in a combined parallel and sequential fashion and therefore requires computational devices and techniques suited and matched to its own characteristics. Although the mechanism of parallel data processing within human nervous system is not yet fully understood, it certainly can be accommodated more readily by some form of optical data processing which also is parallel in nature. In this connection, it might be pointed out that some recent investigation by Prybram, a psychiatrist at Stanford University, indicate that mental processes are somewhat akin to the formation of a hologram by a coherent light. It might be also pointed out that holographic techniques are being developed in conjunction with thick emulsions or crystalline substances which are capable of high density information storage (almost comparable to that of the human brain) and also are capable of associative processes. Hence it appears to me that new computerized techniques and devices based on parallel processing should have been considered.

"b. Another possibility that bears attention is of achieving a data processing mechanism based on analogy to the biochemical processes within organic cells which recently are becoming more understood. From a strictly thermodynamic point of view, it is doubtful whether a system incapable of producing its own entropy source would be ever capable of simulating the behavior of a human mind. From all known physical systems, only those capable of chemical reactions have that property.

"c. It may be worthwhile to consider an actual simulation or gaming of a real battle situation to assess quantitatively the sensitivity of the outcome to various intelligence activities at different levels of organization. Many parametric studies on battle scenarios have been performed which could be used in connection with intelligence processing. The latter could identify which particular model is germane to a situation at hand. Such scheme of information utilization

is somewhat akin to an adaptive control mechanism and requires lesser sensitivity of the control mechanism. In order to be able to use such an approach, however, it is necessary to determine at which organizational level the knowledge of battle pattern is relevant to the decision making. It may turn out that at too low a level the intelligence gathering constitute a rather irrelevant activity from the point of view of the overall battle plan.

"d. It seems to me that new conceptual framework and language might be necessary in future automated intelligence activities. Such a conceptual development should be based not so much on the ingrained linguistic concepts of today which are based on a day to day physical experience but should be related to those elements entering the battle which are relevant to the understanding of battle situations from the systems point of view. That might necessitate development of abstract linguistic concepts which bear little relation to those used at the present time. To put it in a slightly different way, the conventional linguistic description is redundant in terms of independent parameters that characterize "states" of the battle situations. Some new pioneering work along those lines in evolving a formal language appropriate to military systems on a minimum redundance basis in terms of missions to be accomplished is presently going on in the Office of the Chief Engineer. Until such a scheme is introduced, I would agree that some form of data compression through symbolic format should be used. I also feel that the discussion participants seem not to be well familiar with recent developments in the study of structure of natural languages. For example, there is no mention anywhere of the rules of transformational grammar which enable the standardization of the syntax in any natural language. In fact such a process seems to be lately on the threshold of mechanization and renders it possible to treat a natural language in a manner of a formal language.

"e. Many software techniques recommended in this report have been actually used in Vietnam with very poor result. It may be interesting to analyze the reasons for that and to understand why those techniques despite their mathematical appeal, such as, pattern recognition, correlation, etc., performed so poorly in actual environment. It seems to me that no amount of formal manipulation of data is adequate if the basic concepts are incongruous with the realities of the situation. It is also evident from on-the-spot inspection of the Army TOS system by Col. Cobey from HQS, AMC, that the actual usefulness of that system in terms of relevant data that it needs to process to obtain the desired intelligence is rather limited at the present time notwithstanding the original design predictions."

APPENDIX K

SUGGESTIONS FOR CURRICULUM DEVELOPMENT AND ANALYSTS' TRAINING ON ADVANCED ADP AIDS

Following is a compendium of ideas which to the AHWG seemed to have merit for monitorship by and inclusion in Intelligence School Curriculae:

a. Determine flexible "thresholds of interest" for each command level in the future field army so that they only receive necessary and sufficient intelligence data.

b. Include a "dissemination code," in the header of each report record in the intelligence data base, that limits distribution of information sources for their protection, and a "dating code" indicating how long a record has significance (the volatility).

c. Facilitate information access by admitting an item to be found under all pertinent search terms without physically replicating the item in the data base.

d. Send captured combat intelligence documents to all interpreters in the vicinity--e.g., by facsimile or the RAND Tablet--so that the interpreter with the smallest workload can take it on. This is only until transliteration and translation are mechanized. Another approach would be to send the document to the center where the workloads of the interpreters are known and where it is directed accordingly.

e. Organize the IO's data base in a general and an individual part; the general part would come with the unit moving in a new location as initial outfitting and ready-made, containing or reflecting strategic intelligence such as enemy tactics and morale, historic data, terrain features, armament--the "order of battle book" information (ESSA, the Environmental Science Service Administration supplies weather, vegetation, air and ocean current data; the individual data base is the changing part containing typically the current surveillance data).

f. Provide for cross-queries so neighboring data bases become accessible for use and possible recommendations as to updating.

g. Count the queries in experimental systems to measure their efficiency and effectiveness.

h. Use the initial systems to introduce IO trainees to ADP by computer aided instruction, prepare them for special theaters like Vietnam, to teach them to build and sub-set a data base and

induce them to model this sub-set to their needs. This program could also prove or disprove the usefulness of a "personal short file" apart from the large intelligence file. (Such a training aid could be an interim hybrid computer-microfilm system in which the computer generates a data base and indexes it for storage at a microfilm interrogation station.)